

Frequency Generation and Control: Improved Vacuum Pump for the Atomic Hydrogen Frequency Standard

H. Erpenbach and P. Dachel
Communications Elements Research Section

This article describes the use of a turbo-molecular pump as an alternative to the getter-ion pumping systems normally used with the hydrogen maser; the preliminary results were excellent. The time required for pumpdown is about one-third that of the ion pump system. Argon, which is normally ion-pumped at a speed of about 5% of that of air, is removed at the same speed as air with the turbo-molecular pump.

The amount of maintenance required for a turbo-molecular is less than for an ion pump; ion pump elements have to be replaced once a year which means turning off the maser, installing new elements, and disturbing the maser, a process which requires several days. Turbo-molecular pump manufacturers claim 5 years or more without servicing.

I. Introduction

A turbo-molecular mechanical vacuum pump was tested as a substitute for an ion pump in a hydrogen maser. This vacuum pump does not operate on the positive displacement principle but rather on the principle of imparting momentum to gas molecules, preferentially in the direction of the desired flow.

In 1912 Gaede (Ref. 1) introduced a molecular-drag pump. In the molecular-drag pump (Ref. 2) there is an open passage from the inlet to outlet between which a pressure differential is maintained by the high velocity

motion of one side of the passage relative to the housing of the pump, where the inlet and outlet are located. In Fig. 1 the principle of the molecular-drag pump is illustrated.

A number of alternative designs for molecular-drag pumps have been devised, but all of them had slow pumping speeds, about 20 liters/sec or less. In 1958 A. Pfeiffer introduced axial-flow molecular turbine pumps, now known as turbo-molecular pumps (Ref. 2). This type of pump has a series of rotating disks (all mounted on the central shaft) that are spaced alternately with stationary plates mounted in the housing. The disks and plates are

cut with slots set at an angle so that gas molecules caught in the slots of the moving disks are projected preferentially in the direction of the slots in the stationary plates. The pumping speed of one new-type turbo-molecular pump is consequently significantly higher, typically 500 liters/second at an inlet pressure of 133.3×10^{-6} N/m² (10^{-6} torr) with an outlet pressure of 133.3×10^{-3} N/m² (10^{-3} torr).

II. Application to System

A 12-year old turbo-molecular vacuum pump capable of 140 liters/sec was installed in place of the 200 liters/sec ion pump. The photograph of the prototype maser (Fig. 2) shows the details of the installation of the turbo-molecular pump.

The letter "A" in the photograph is the turbo-molecular pump; "B" is a 15-cm (6 in.) stainless steel bellows; "C" is

the extension for the source to make it the same distance from the cavity as the original installation using the ion pump. The slight mechanical vibration of the pump was successfully isolated from the maser by the bellows and suitable shock mounts.

III. Performance

The turbo-molecular vacuum pump will evacuate a hydrogen maser in 30 minutes. An ion pump under the same condition would take at least 3 hours. The turbo-molecular pump has no high-voltage arcing problems. An ion pump operates on 5000 Vdc and has occasional internal flashovers in the pump which produce undesirable electrical noise.

It is not anticipated that the turbo-molecular vacuum pump will replace the ion pump in the near future, as much more time is needed for evaluation of the system.

References

1. Gaede, W., *Ann. Physik*, Vol. 41, p. 337, 1913.
2. Becker, Von W., "A New Molekular Pump," in *Vakuum-Technik*, pp. 149-152. Rudolf A. Lang, Berlin, October 1958.

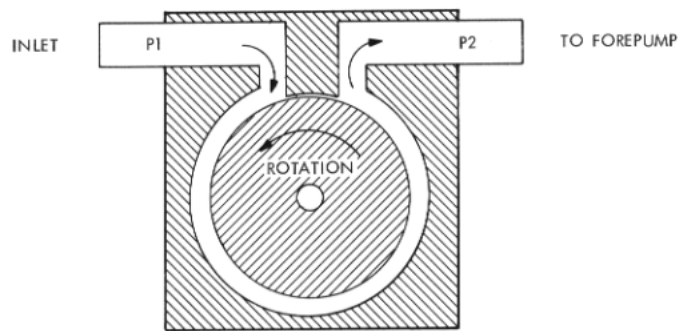


Fig. 1. Molecular drag pump schematic diagram

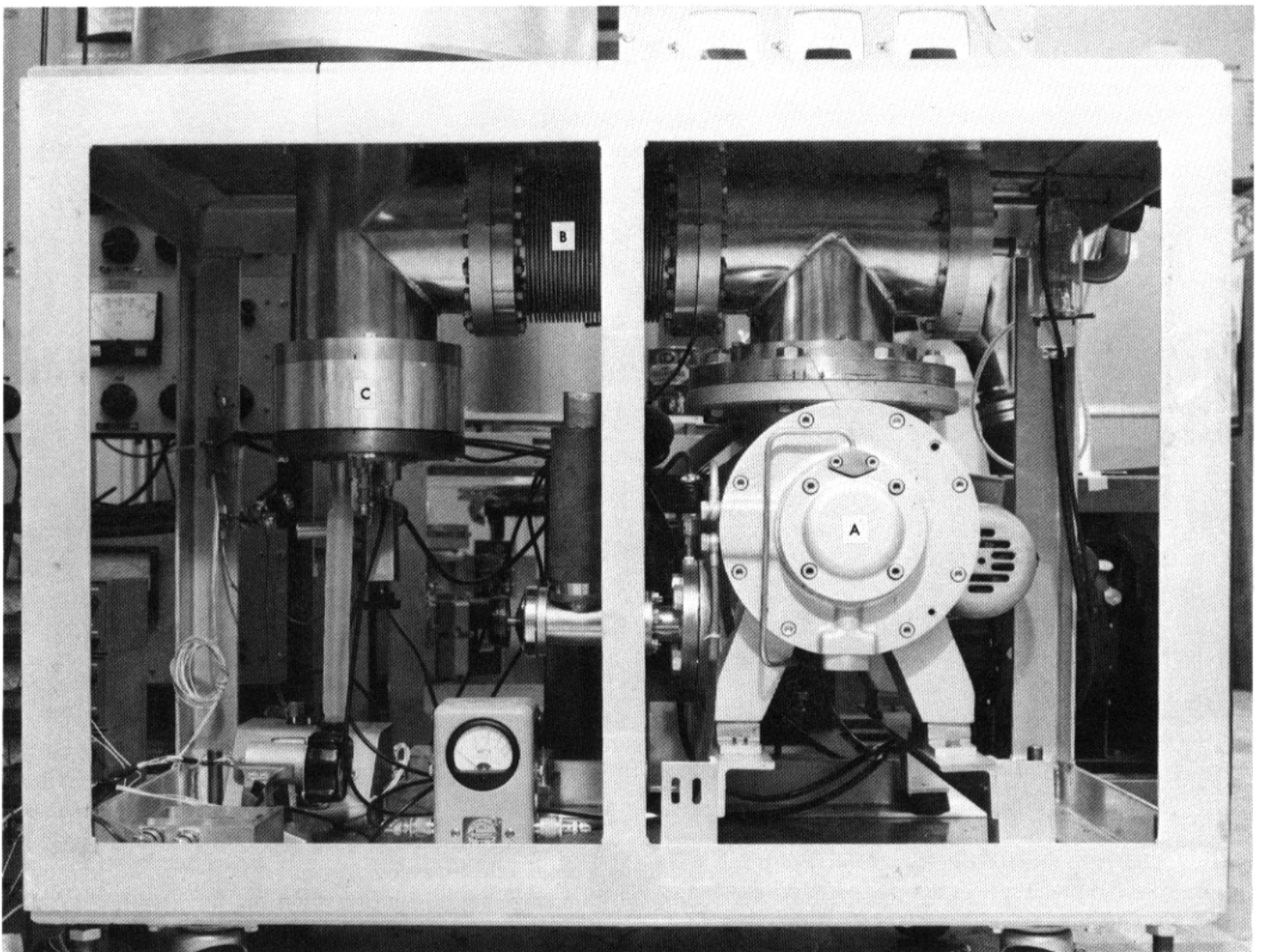


Fig. 2. Turbo-molecular pump vacuum system